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Tropospheric Emission Spectrometer
Aura Validation Working Group
Meeting – Oct 27, 2008

Update on TES L2 Validation Status

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TES Science and Validation Team
Jet Propulsion Laboratory/California Institute of Technology

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- The **Version 3** TES data includes:
 - Limb profiles valid into the upper troposphere
 - Improvements to the temperature retrievals (updated CO₂ spectroscopy)
 - Improvements to the methane retrievals
 - Species dependent quality control information
 - Use of GMAO GEOS-5.1.0 products in L2 retrievals
 - O₃, CO, H₂O, HDO, TATM , SST validated with known biases
 - CH₄, Limb Products provisionally validated
 - F04_04 in filename
- TES Version 3 data products began processing January 2007
 - Complete reprocessing completed (Sep 2004 – Sep 2008)
- TES data and documentation can be found:
 - Langley Atmospheric Science Data Center (<http://eosweb.larc.nasa.gov/>)
 - Aura Validation Data Center (<http://avdc.gsfc.nasa.gov/>)
 - TES L2 Data User's Guide available at both sites
 - TES L2 Validation Report available at both sites



- The **Version 4** TES data will include:
 - Limb profiles valid into the upper troposphere
 - Improvements to the temperature retrievals (updated CO₂ spectroscopy)
 - Improvements to the methane retrievals
 - Species dependent quality control information
 - Use of GMAO GEOS-5 products in L2 retrievals
 - F05_05 in filename if GMAO GEOS-5.1.0
 - F05_06 in filename if GMAO GEOS-5.2.0
- Data production began September 2008 (forward processing)
 - Full reprocessing expected by mid-2009
- Preliminary validation analyses are underway



Tropospheric Emission Spectrometer **TES Level 2 Data Version 4: Validation Update**

- The **Version 4** TES data has undergone *preliminary* validation analyses (processing began in early Sep 2008)
- Improvements to nadir temperature key feature of V04 data
 - Bias improved to less than 0.5K compared to sondes at nearly all altitudes
 - Bias at 400 hPa is ~0.7K
 - See R Herman et al. poster presentation on Wednesday
- TES nadir methane retrievals processed as “representative tropospheric VMR” are biased 3-4% high relative to aircraft data
 - See V Payne et al., presentation – Wed 4:45
- Minor changes to ozone retrievals
 - High bias of 3-10 ppbv (sondes) in V02 data
 - V02, V03 and V04 data consistent
 - More successful quality retrievals in V04
 - Fewer cases with anomalous high ozone at surface in V04
- V04 carbon monoxide, nadir water, HDO, limb products consistent with V03



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Tropospheric Emission Spectrometer

Current Validation Status: V03

Species	Validation Status
Nadir Ozone	Validated Stage 2
Nadir Carbon Monoxide	Validated Stage 2
Nadir Water	Validated Stage 2
Nadir Temperature	Validated Stage 2
Sea Surface Temperature	Validated Stage 2
Land Surface Temperature/Emissivity	Provisionally Validated
Nadir Methane	Validated Stage 2
Nadir HDO	Validated Stage 1*
Limb Nitric Acid	Provisionally Validated
Limb Ozone	Provisionally Validated
Limb Temperature	Provisionally Validated
Limb Water	Beta – Used as interferent for retrievals of other limb products



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Tropospheric Emission Spectrometer Expected Validation Status: V04 Mid-2009

Species	Validation Status
Nadir Ozone	Validated Stage 2
Nadir Carbon Monoxide	Validated Stage 2
Nadir Water	Validated Stage 2
Nadir Temperature	Validated Stage 2
Sea Surface Temperature	Validated Stage 2
Land Surface Temperature/Emissivity	Validated Stage 2
Nadir Methane	Validated Stage 2
Nadir HDO	Validated Stage 2
Limb Nitric Acid	Validated Stage 2
Limb Ozone	Validated Stage 2
Limb Temperature	Validated Stage 2
Limb Water	Beta – Used as interferent for retrievals of other limb products



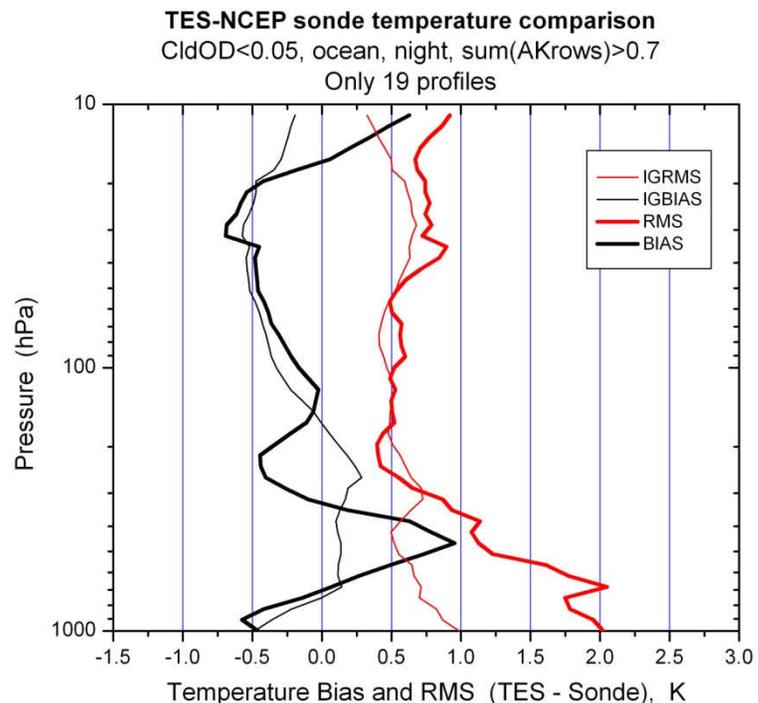
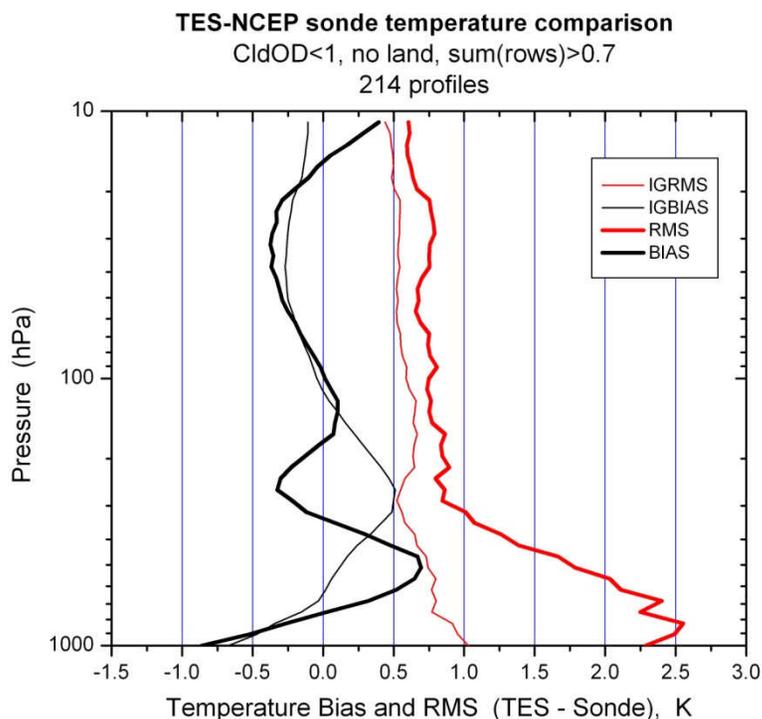
Tropospheric Emission Spectrometer

Validation Status Definitions

Term	Definition
Beta	Early release products for users to gain familiarity with data formats and parameters.
Provisional	Limited comparisons with independent sources have been made and obvious artifacts fixed.
Validated Stage 1	Biases are estimated from independent measurements at selected locations and times. ** TES L2 retrievals include fully, internally characterized error estimates **
Validated Stage 2	Biases are estimated from more widely distributed (often global) independent measurements.
Validated Stage 3	Biases are estimated from independent measurements representing global conditions.



- TES v004 compared with RS-90 and RS-92 sondes from NCEP database within ± 3 hours and ± 100 km.
- T bias (black): within ± 1 K at all levels, typically within ± 0.5 K of NCEP except at 400-500 hPa.
- T RMS (red): RMS is similar to IG RMS, except in the lower troposphere, where there is significant natural variability.
- See R Herman et al. poster presentation on Wednesday

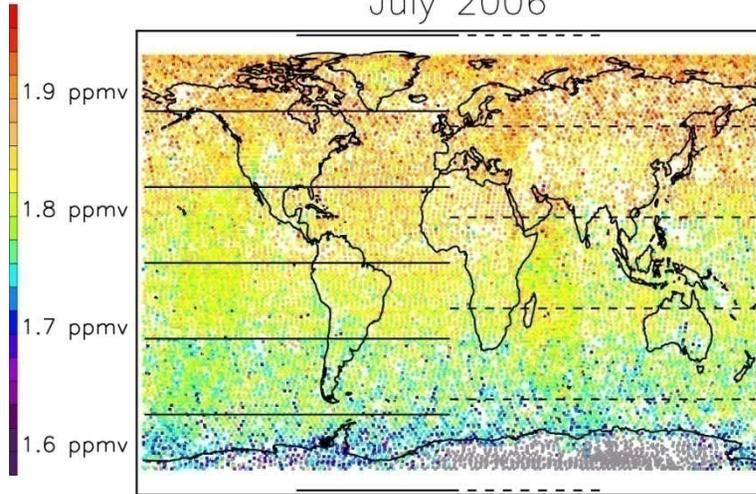




Tropospheric Emission Spectrometer Representative Tropospheric VMR results for CH₄

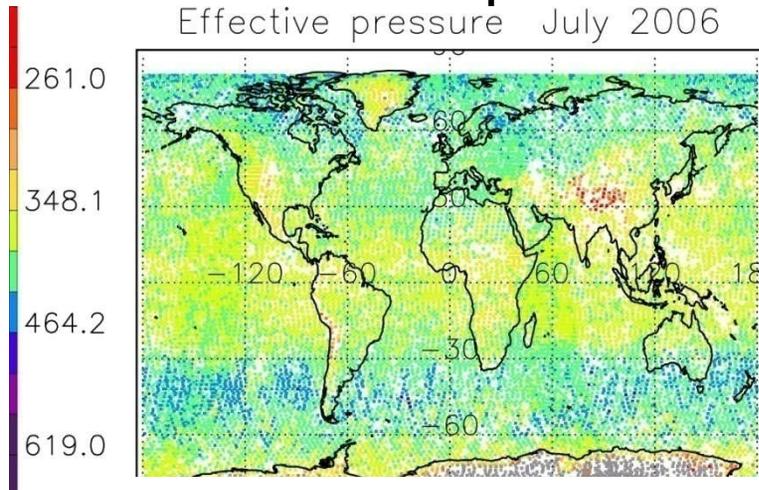
“RTVMR” for July 2006

July 2006

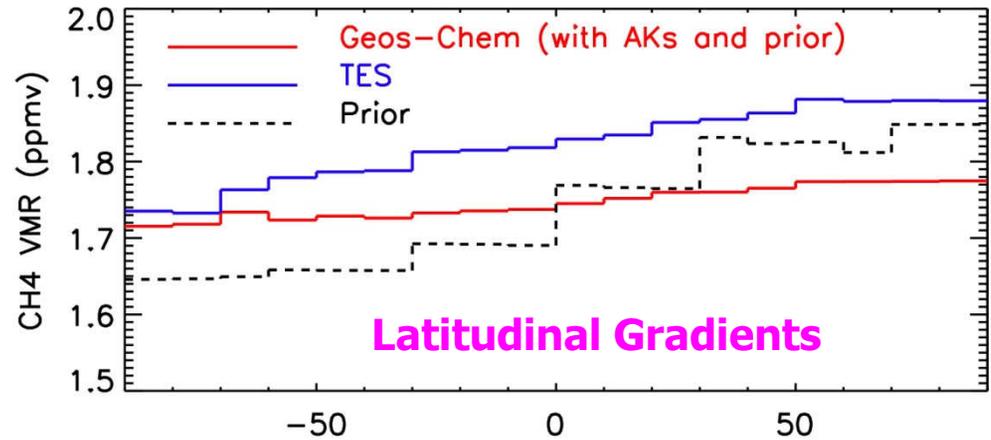


“Effective pressure”

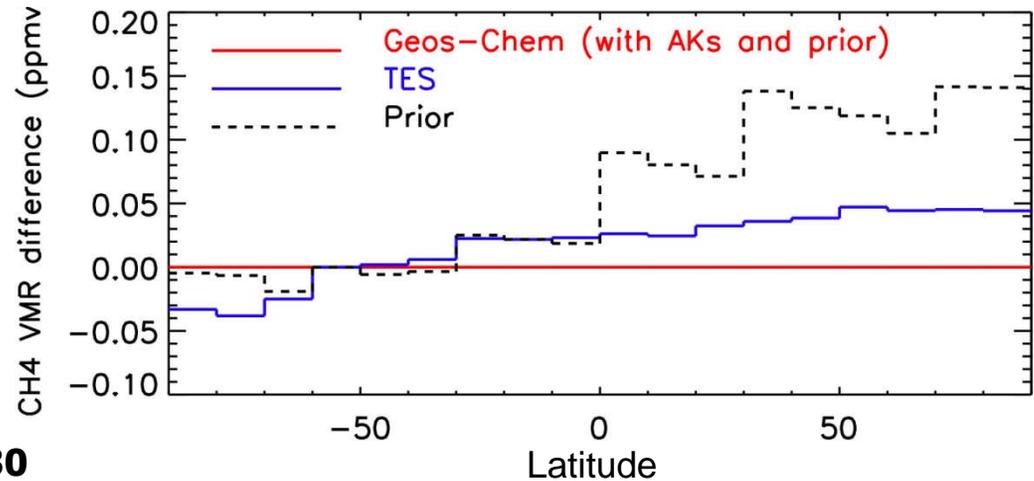
Effective pressure July 2006



July zonal means



Difference from GEOS-Chem, after bias removal at 50S-60S



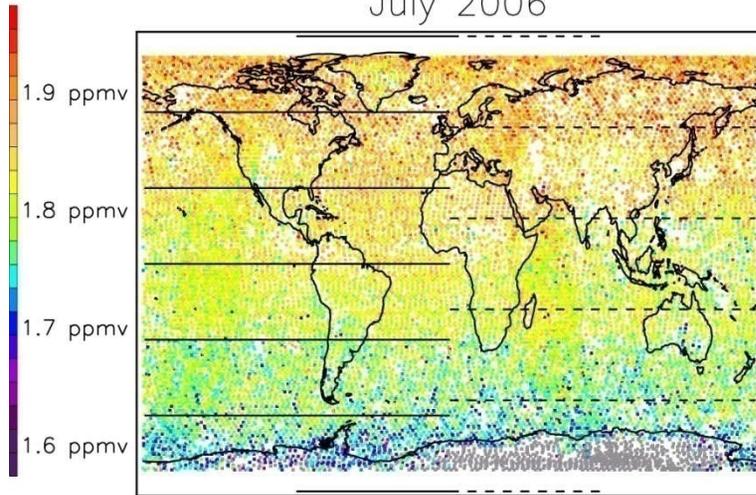
See V Payne’s Talk – Wednesday at 2:30



Tropospheric Emission Spectrometer Representative Tropospheric VMR results for CH₄

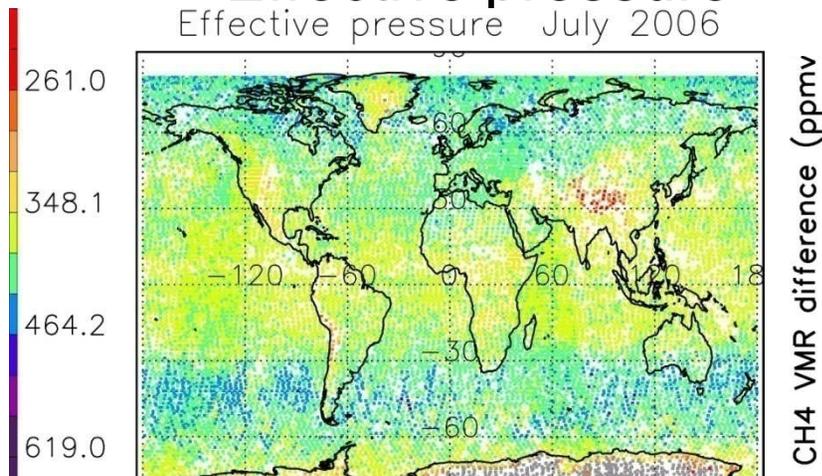
“RTVMR” for July 2006

July 2006



“Effective pressure”

Effective pressure July 2006



CH₄ VMR (ppmv)

CH₄ VMR difference (ppmv)

- TES CH₄ is most sensitive in the mid to upper troposphere with ~1 DOF
- Representative tropospheric VMR: Single troposphere VMR value specified at an effective pressure
- TES latitudinal gradients are realistic
- TES shows high bias of wrt GEOS-Chem (3.5% bias at 50S-60S in January)
- TES shows high bias of 3.5 % wrt DACOM in-situ aircraft data

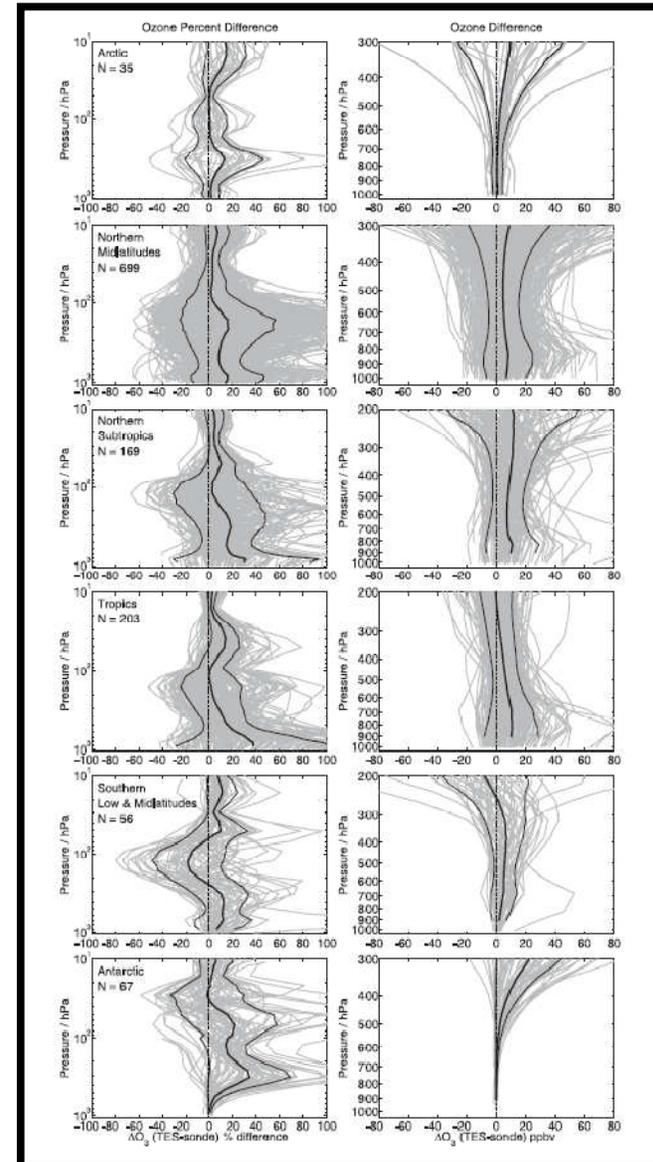
See V Payne's Talk – Wednesday at 2:30



Tropospheric Emission Spectrometer TES Nadir Ozone Validation Overview (V02)

- Seasonal/Latitudinal statistics with ozonesonde comparisons
- High bias of 3-10 ppbv (sondes)
- High bias of ~7 ppbv (DIAL Lidar)
- Stratospheric column ~3 DU high compared with MLS
- Total column ~10 DU high compared with OMI
- Atmospheric variability affects the observed differences
- Analyses primarily using V002 data
- Relative variations in ozone measured by TES meaningful

R Nassar et al., 2008
N Richards et al., 2008
G Osterman et al., 2008



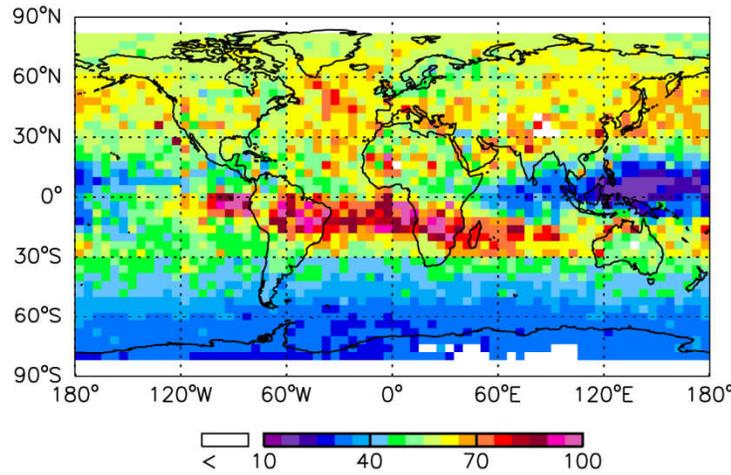


Tropospheric Emission Spectrometer

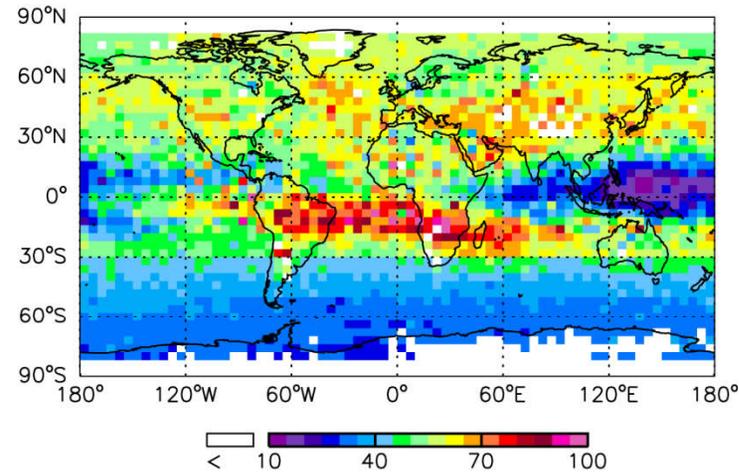
C-Curve retrievals in TES V03 ozone data

October 2005, ozone at 618 hPa averaged on 4x5 resolution

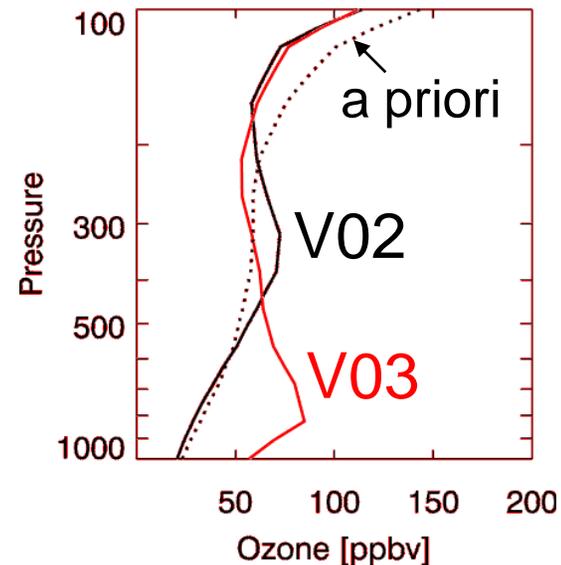
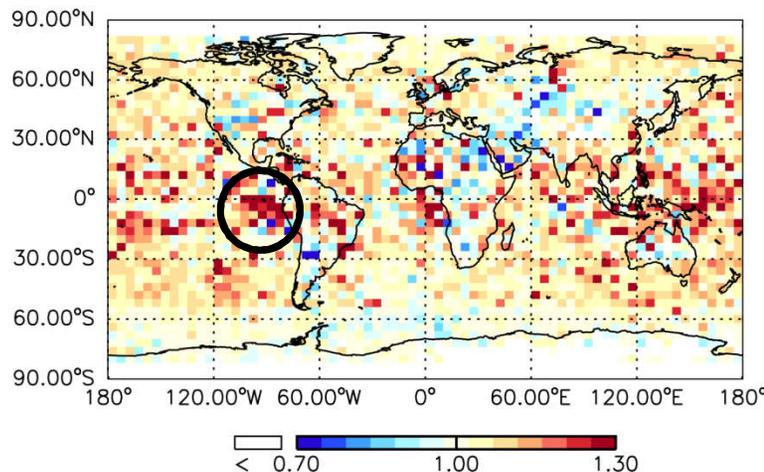
V03 ozone



V02 ozone



Ratio V03/V02



See L Zhang's Talk – Tuesday at 2:30



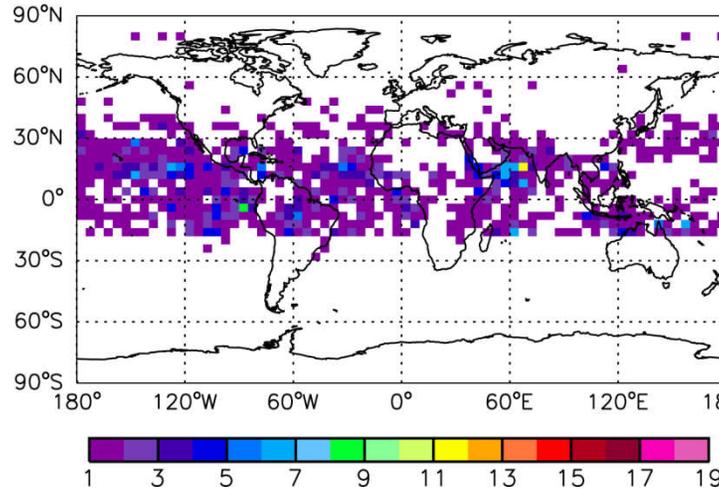
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C-Curve test for TES V03 O₃ data

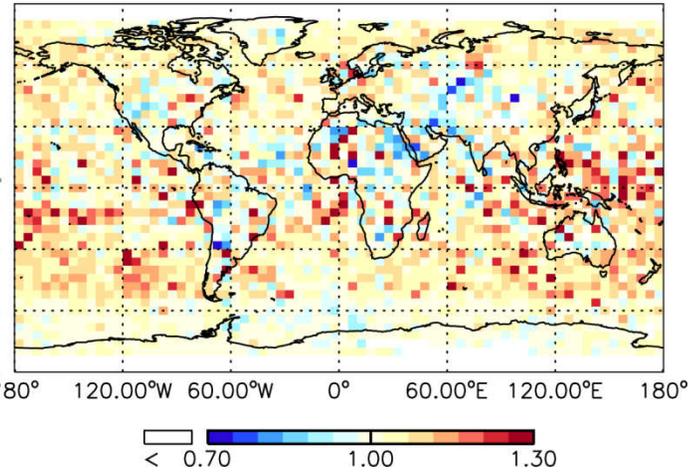
October 2005

TES C-Curve
Flag

Number of obs filtered

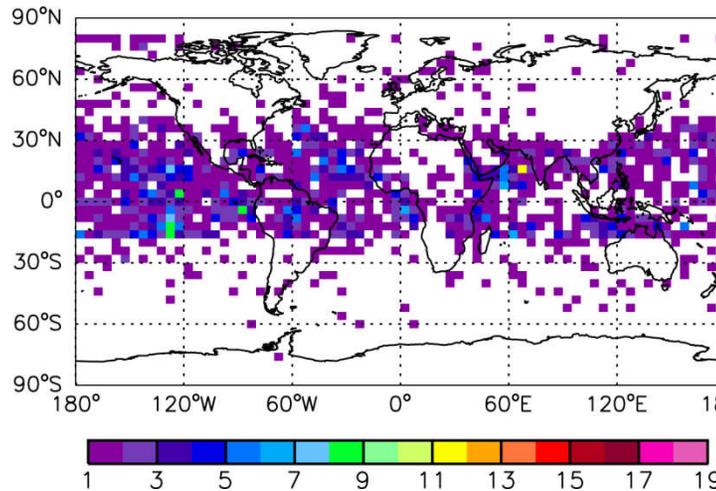


Ratio V03/V02 after test

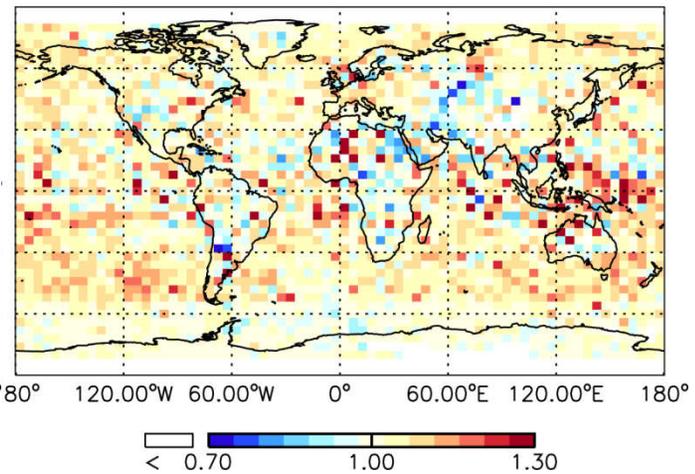


Zhang test

Count O3, October 2005



Ratio V03/V02

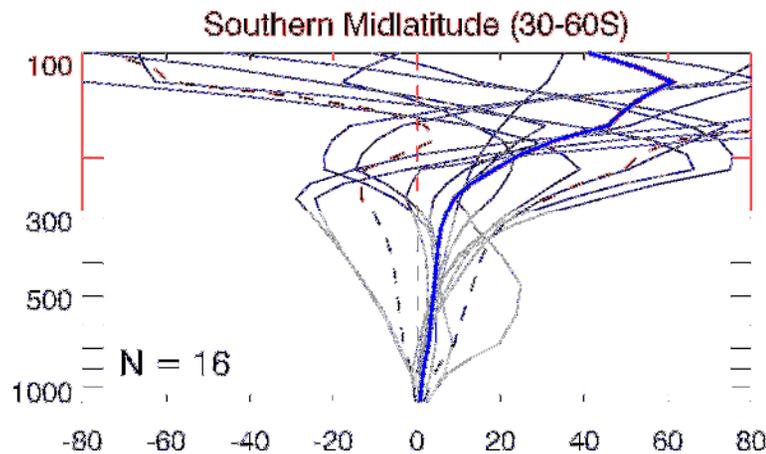
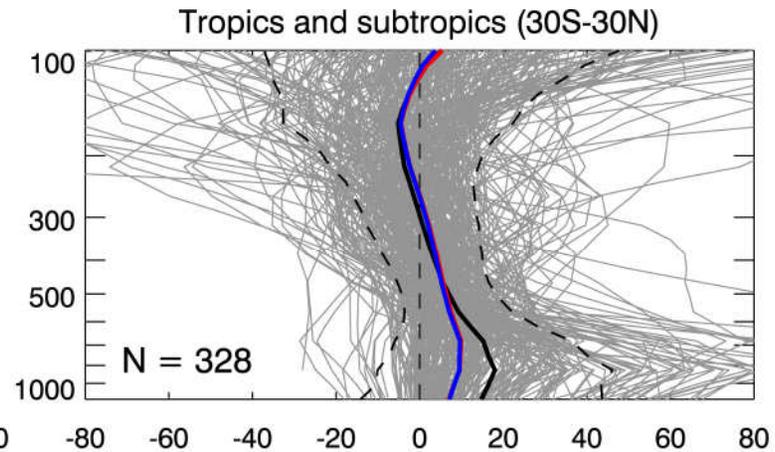
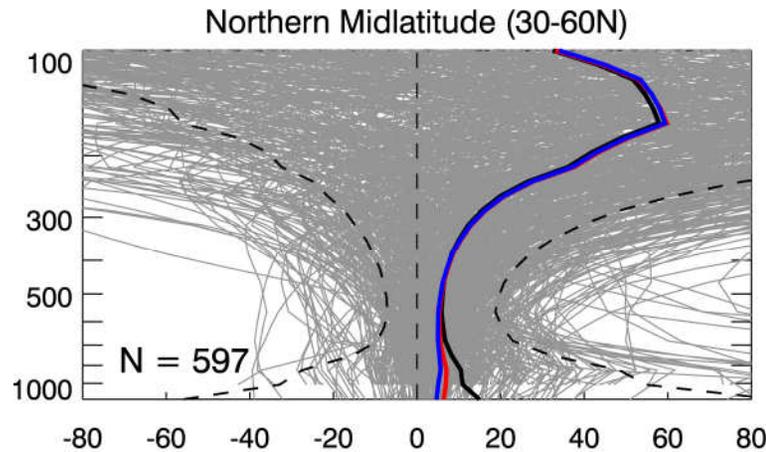


See L Zhang's Talk – Tuesday at 2:30



Tropospheric Emission Spectrometer

TES V03 Ozone Validation



V03 Master C-Curve Worden-test Zhang-test

Ozonesonde data from 2005-2007, available at AURA AVDC

Coincidence Criteria: $< 2^\circ$
longitudes & Latitudes, < 10 hours

High bias of 3-10 ppbv in the
troposphere with the C-curve test
applied.



Tropospheric Emission Spectrometer **Recommendations when using TES ozone data**

- V02 data is a thoroughly validated version of the TES nadir ozone product
- V03 data is largely consistent with V02 (as suggested by lidar and total column comparisons)
 - Some spatial differences (observed in monthly maps).
 - Differences in the occurrence of high surface/very low mid troposphere ozone cases (referred to as “C-curve” cases) observed in comparisons to ozonesondes
- V04 data validation is currently ongoing, early results suggest:
 - Higher number of good ozone profiles compared to V03
 - A decrease of more than 50% in C-curve cases compared to V03
 - There will be a full sonde validation analysis for V04 data (analyst/author TBD) and could be expanded to include the TES limb ozone product



Tropospheric Emission Spectrometer **Recommendations when using TES ozone data**

- C-curve ozone profiles in TES data occur in ~5% of the V03 ozone retrievals
- C-curve profiles tend to be a problem in the following cases:
 - Tropical observations
 - Locations very close to land/sea boundaries
 - Mountainous terrain
 - Desert terrain
- In these observing locations, the data user should use both the ozone master quality flag and test for C-curve cases
- The V03 TES ozone master quality flag does not include a condition for C-curve cases.
 - No C-curve flag in the V03 data product
 - Pseudo-code for a C-Curve flag is available in the TES L2 Data User's Guide
- The V04 TES ozone master quality flag also does not include a condition for C-curve cases
 - There is a C-curve flag included in the data product based on the pseudo-code described in the Data User's Guide.



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Tropospheric Emission Spectrometer **Recommendations when using TES ozone data**

- Lin Zhang at Harvard University has developed an alternate test for C-curve profile in the TES ozone product
 - Preliminary tests with V03 data show it to be very effective at screening out potentially anomalous high surface ozone values
 - Pseudo-code for this version of the flag will be included in the Data User's Guide
- TES ozone profiles flagged as C-curve cases are likely anomalous, but not necessarily always that way.
 - The flag could screen out actual cases of high ozone in the lowest portion of the troposphere.



Tropospheric Emission Spectrometer

TES Validation Data Requirements

- Current TES Validation Data Requirements

Species	Priority	Requested Data	Justification
L1B Radiances	High	AIRS, Scanning-HIS	More “clear sky” Scanning-HIS data for monitoring of L1B data quality
Surface Emissivity	High	Aircraft	Better characterization of sea ice/water in Arctic and Antarctic
HDO	High	Aircraft Data	Data between 500-700 hPa Mauna Loa Campaign Currently Ongoing
CH ₄	High	DACOM	Middle Tropospheric Profile Data
TATM, H ₂ O, O ₃	Moderate	Ozonesondes, CFH sondes	CFH sondes – Clear sky, Ocean scenes (Separation of effects for systematic errors – AER)
Nadir O ₃	Moderate	Ozonesondes	More sonde data to improve statistics and in tropical ocean scenes (TC4-Guam/SHADOZ)



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